Human Spaceflight Capabilities

Integration of iRevive with the Lightweight Trauma Module

Completed Technology Project (2009 - 2011)

Project Introduction

Key to this system is the collection and presentation of data. This has required: 1) rewriting the iRevive GUI and database codebase using current technology; 2) defining the communication protocol between the LTM and iRevive; and 3) building a LTM simulator to debug the iRevive-LTM communication protocol, which was hardcoded into the LTM. In the past year we have rewritten the GUI and database for iRevive to increase the speed, portability, and maintainability of the codebase, which is now in Python for improved interaction with the Internet and the world wide web. The GUI has improved graphics and more complete pull down menus, to facilitate ease of use and generate a more complete record with less user training required. Another focus has been defining a communication protocol for the LTM to exchange data with iRevive. This protocol was implemented as an LTM simulator for testing, debugging, and then in a FPGA. Our approach defined a base protocol to transmit parametric vital sign information. It was then extended to transmit wave type data, alarms, device configuration, and connection initiation. This effort produced a high-level protocol specification. We are using traditional Internet protocols, including UDP at the transport layer to exchange end-to-end packets. This information includes a sequence number, time stamp, packet type, and meta information describing the data from the LTM. The packet format defines all parametric vital sign data from each device module in the LTM, including SpO2, EtCO2, temperature, invasive and non-invasive blood pressure, ECG, and ventilator settings. These packets contain meta information, which describes attributes such as when measurements should be flagged with an alarm and the measurement units. The packet format also defines device alarms including their priority, how an alarm is indicated to the user (i.e., audible and latching), and information unique to each LTM device module. Work was also done to define the protocols and processes required for waveform data as well as an initiation protocol. Waveform data will be displayed with allowable ranges. Initiation protocols will synchronize these ranges and timing as well as provide the connection between LTM and iRevive. As the funding period is now complete, and the defined goals reached, the technical, funding, and schedule risk for this proposal are by definition low or non-existent.

Anticipated Benefits

Civilian pre-hospital providers (e.g., paramedics and emergency medical technicians) collect and act upon a wide variety of complex visual clues, while monitoring and adjusting to continually changing sets of vital signs. Pre-hospital vital sign information in the form of trending data is rarely integrated into the patient care record, so how the vital signs change in response to specific treatment measures is largely undocumented and poorly understood. As a consequence, the care that is provided to a patient in the field is anticipatory and reactive. It is not time sensitive and the accompanying patient medical record is oftentimes incomplete. Healthcare providers do not

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give medications or adjust the ventilator and IV fluids as often or as accurately as a smart, vigilant system might and, as a result, patients likely do not respond or recover as quickly as they could. We have developed a fully integrated system for mobile critical care patient support and documentation. The iRevive-LTM system is composed of physiological sensors, monitors, and therapeutic hardware devices, linked by a suite of software applications. The components integral to the LTM include: a ventilator; 3/5/12-lead ECG (electrocardiogram); pulse oximeter; noninvasive blood pressure (NIBP); end-tidal carbon dioxide (EtCO2); patient temperature; invasive arterial and intracranial pressure monitoring capabilities; Ethernet communications; closed-loop control of oxygenation (and soon ventilation and IV fluid control); an integrated electronic medical record (iRevive) for clinical data storage and export; alarming, and smart help. The LTM supports up to three external intravenous (IV) pumps and is designed to support other to be developed noninvasive monitors, all connected via powered-USB ports. It supports several additional modules, including an oxygen concentrator, patient warming, and an anesthesia control module. Software will oversee a growing number of autonomous care applications within the integrated system, which will reduce the need for constant attention by a healthcare provider or crew medical officer. While space flight design requirements are of paramount importance to the current project, we are cognizant of U.S. military funding and civilian needs for improved transport monitoring technology. The small, lightweight, rugged, low power design specifications for space flight are equally important here on Earth. A transport monitor that goes into space should have facility for remote calibration and maintenance, as should a transport monitor that is deployed on the battlefield or in other remote locations. Incorporation of redundant systems, automated alarms and, increasingly, closed loop control algorithms will be essential. The value of consolidating patient monitoring, support, and documentation into a single system, capable of automatically collecting and transmitting real-time patient care data, cannot be overemphasized. Integrating these data streams has many advantages, not only in providing real-time information display both locally and centrally for triage decision support, but in trauma system development. More importantly, the physiologic and electronic patient care data that will be captured by the iRevive-LTM system will be fully integrated and time synchronized. New state-of-the-art machine learning, feature extraction, and advanced statistical methods are showing great promise in analyzing these types of complex data sets, uncovering many important, previously hidden physiological relationships and treatment effects. As these relationships are further defined and understood, our models of health and disease will become more complex and accurate. They will provide more reliable, real-time insight into the current and predicted future status of our patients. In time, machine-based comprehension of semantic clinical information together with real-time physiological data will lead to the development of fully autonomous patient care systems.

Organizational Responsibility

Responsible Mission Directorate:

Space Operations Mission Directorate (SOMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Human Spaceflight Capabilities

Project Management

Program Director:

David K Baumann

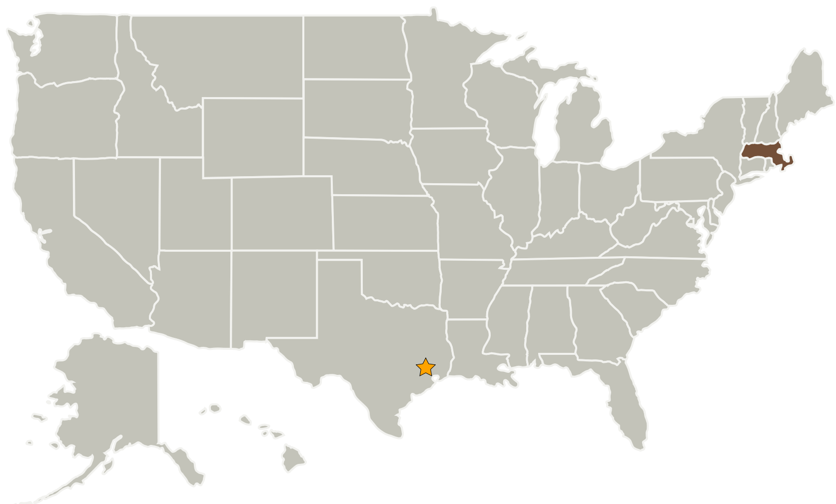
Principal Investigator:

John P Crossin

Co-Investigators:

Daniel Myung
Mark Gaynor
George J Beck
Thomas R Hatfield
Steven Moulton

Primary U.S. Work Locations and Key Partners

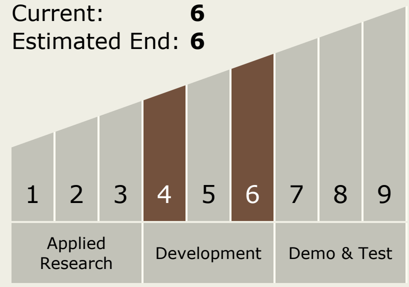


Organizations Performing Work	Role	Type	Location
☆Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
10 Blade, Inc.	Supporting Organization	Industry	
Impact Instruments	Supporting Organization	Industry	
Saint Louis University	Supporting Organization	Academia	Saint Louis, Missouri
Wyle Laboratories, Inc.	Supporting Organization	Industry	

Primary U.S. Work Locations
Massachusetts

Technology Maturity (TRL)

Start: **4**
Current: **6**
Estimated End: **6**



Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - └─ TX06.3 Human Health and Performance
    - └─ TX06.3.1 Medical Diagnosis and Prognosis

Target Destinations

The Moon, Mars

Project Transitions

September 2009: Project Start

August 2011: Closed out

Closeout Summary: Key to this system is the collection and presentation of data. This has required: 1) rewriting the iRevive GUI and database codebase using current technology; 2) defining the communication protocol between the LTM and iRevive; and 3) building a LTM simulator to debug the iRevive-LTM communication protocol, which was hardcoded into the LTM. In the past year we have rewritten the GUI and database for iRevive to increase the speed, portability, and maintainability of the codebase, which is now in Python for improved interaction with the Internet and the world wide web. The GUI has improved graphics and more complete pull down menus, to facilitate ease of use and generate a more complete record with less user training required. Another focus has been defining a communication protocol for the LTM to exchange data with iRevive. This protocol was implemented as an LTM simulator for testing, debugging, and then in a FPGA. Our approach defined a base protocol to transmit parametric vital sign information. It was then extended to transmit wave type data, alarms, device configuration, and connection initiation. This effort produced a high-level protocol specification. We are using traditional Internet protocols, including UDP at the transport layer to exchange end-to-end packets. This information includes a sequence number, time stamp, packet type, and meta information describing the data from the LTM. The packet format defines all parametric vital sign data from each device module in the LTM, including SpO2, EtCO2, temperature, invasive and non-invasive blood pressure, ECG, and ventilator settings. These packets contain meta information, which describes attributes such as when measurements should be flagged with an alarm and the measurement units. The packet format also defines device alarms including their priority, how an alarm is indicated to the user (i.e., audible and latching), and information unique to each LTM device module. Work was also done to define the protocols and processes required for waveform data as well as an initiation protocol. Waveform data will be displayed with allowable ranges. Initiation protocols will synchronize these ranges and timing as well as provide the connection between LTM and iRevive. As the funding period is now complete, and the defined goals reached, the technical, funding, and schedule risk for this proposal are by definition low or non-existent.

Project Website:

https://taskbook.nasaprs.com